Implementing HYCOM as an Operational Model at NAVO

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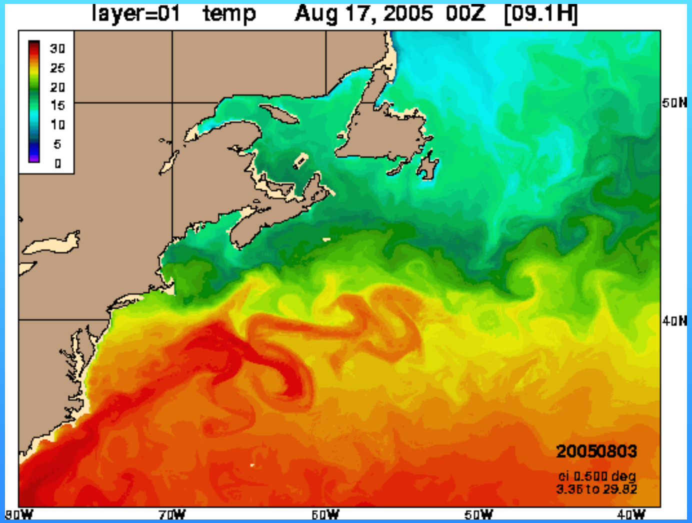
HYCOM Consortium Meeting
24-26 April 2007



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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **APR 2007**	2. REPORT TYPE	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **Implementing HYCOM as an Operational Model at NAVO**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Meteorology and Oceanography Command,Naval Oceanographic Office (NAVO),1100 Balch Blvd,Stennis Space Center,MS,39529**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
11th HYCOM Consortium Meeting, Apr 24-26, 2007, Stennis Space Center, MS

14. ABSTRACT
A discussion of the practical aspects of modeling like schedules, computer asset requirements, data flows (in internal and out), NAVOCEANO and MSRC infrastructure model products (construction, delivery, archiving), policy hurdles, the movement from R&D through system installation to operational in real-time, etc. That is, how NAVOCEANO takes the work of science and turns it into production.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**17**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Outline

1. OCEAN MODEL APPLICATIONS

2. INSTALLATION AT NAVOCEANO

3. THE TRANSITION PROCESS

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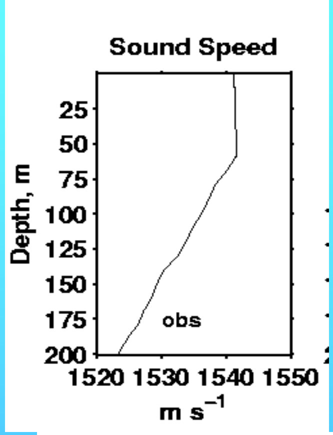
1. OCEAN MODEL APPLICATIONS

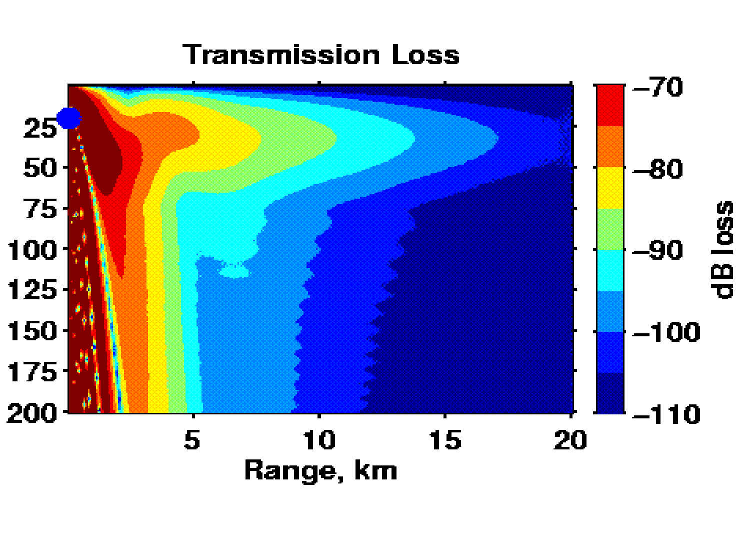
- Navy business - fight and win wars
- Ocean knowledge - a force multiplier
- Products for Navy customers
  - ASW
    - Sound speed
    - Fronts and eddies
    - Deep water to coastal regions
  - MIW
    - Currents
    - Coastal to deep water
  - NSW
    - Currents, waves
    - Nearshore, beaches, estuaries
  - Fleet Operations – amphibious landings
    - Nearshore currents
    - Surf zone

Public web images

ASW – Forecasting Sound Speed Structure

- Surface duct
  - Sound trapping wave guide (mixed layer, sonic layer)
  - Frequency trapped relative to inverse of thickness
  - Cylindrical spreading
  - Sound loss due to reflection (roughness-waves) and leakage to deep
- Structure of sound speed
  - Vertical wobbles – internal tides change surface duct thickness
  - Variations change ensonification
  - Diurnal surface warming – changes duct form



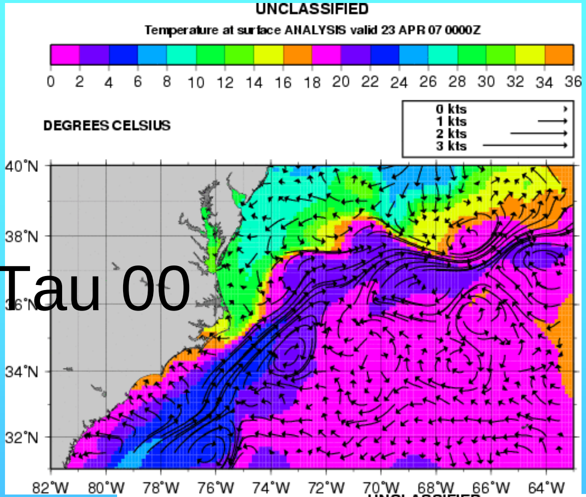


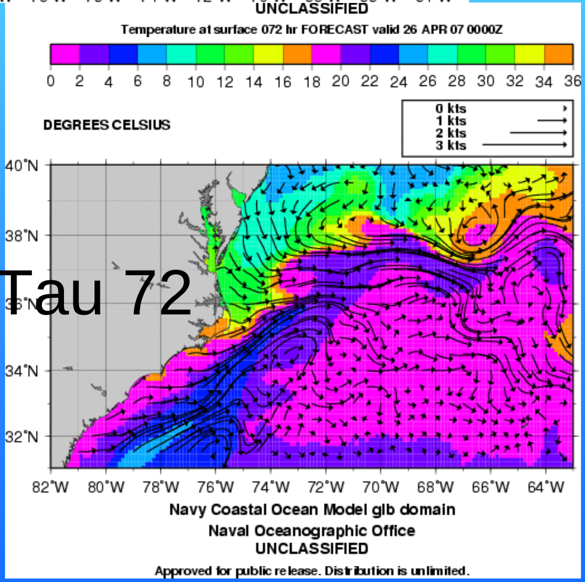
Bob Helber, Charlie Barron (NRL) – personal communication

Forecast Requirements

- 3D ocean – eddies and fronts change horizontal structure
  - Location and structure affect sound propagation
  - Movement (advection) means changes that affect ASW

- Forecast Periods
  - 2 days – synoptic or real time (model run finishes and delivered at about +18 hours)
  - 3 days –tactical or tomorrow's fleet placement
  - 7 days – strategic or plan the next few days





Global NCOM - East Coast

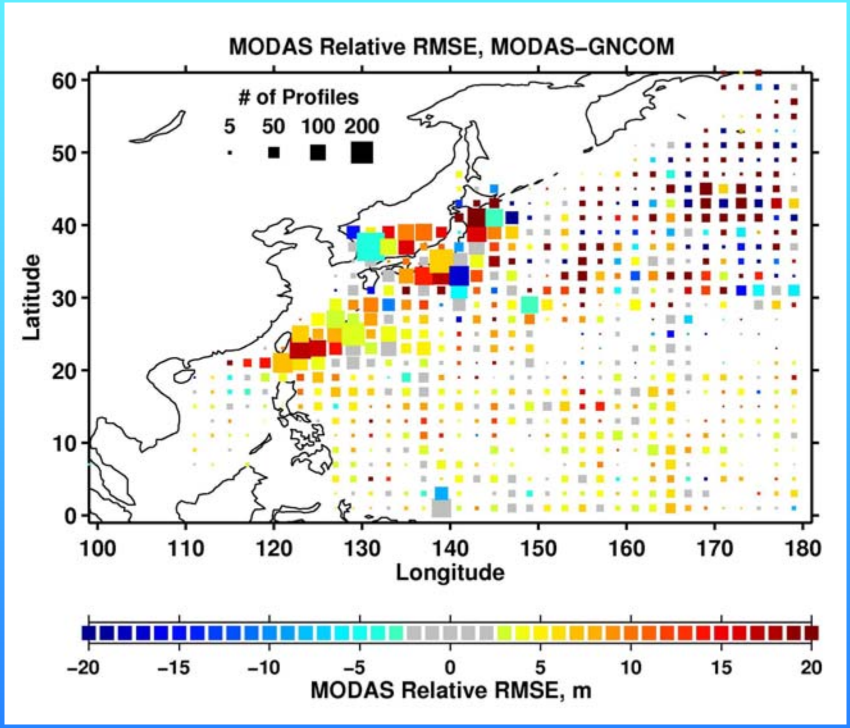
Aside: Model Resolution Questions

- What **improvements** does 1/12 or 1/25 degree bring us over 1/8 G-NCOM?
- Should we run global **1/25** or a **1/12** resolution with nested high resolution domains (**1/30, 1/60**) in areas of interest?
- What **resolution** is required to resolve Navy applications?
- What does **higher spatial resolution** give us scientifically
  - If 5 grid-points define a feature, is a 12 nm eddy relevant to ASW?
  - Can we actually get the high-res physics right or is parameterization all that really works now?
- Same question for time
  - Does a **1-hour** time step mean anything outside strongly tidal regions?
- Balance science with capabilities
  - A **2X** increase in 3D resolution means **8X** the storage space and **10X** the computational requirements
  - Can we move the additional data around, store it, will we use it again?

Assessing Model Skill is Important

- Need to be able to show how the model is degraded over scales of time and space
- Real-time data assimilation expected
  - Adjust model start field to “reality” of observations
  - Provides indicators of uncertainty
- Ensemble approach – perturbations indicate variability
- Correlation length scales
  - How to observe and set model resolution
- Required by Navy to determine Fleet risks for ocean-related actions

How much better than MODAS is GNCOM?



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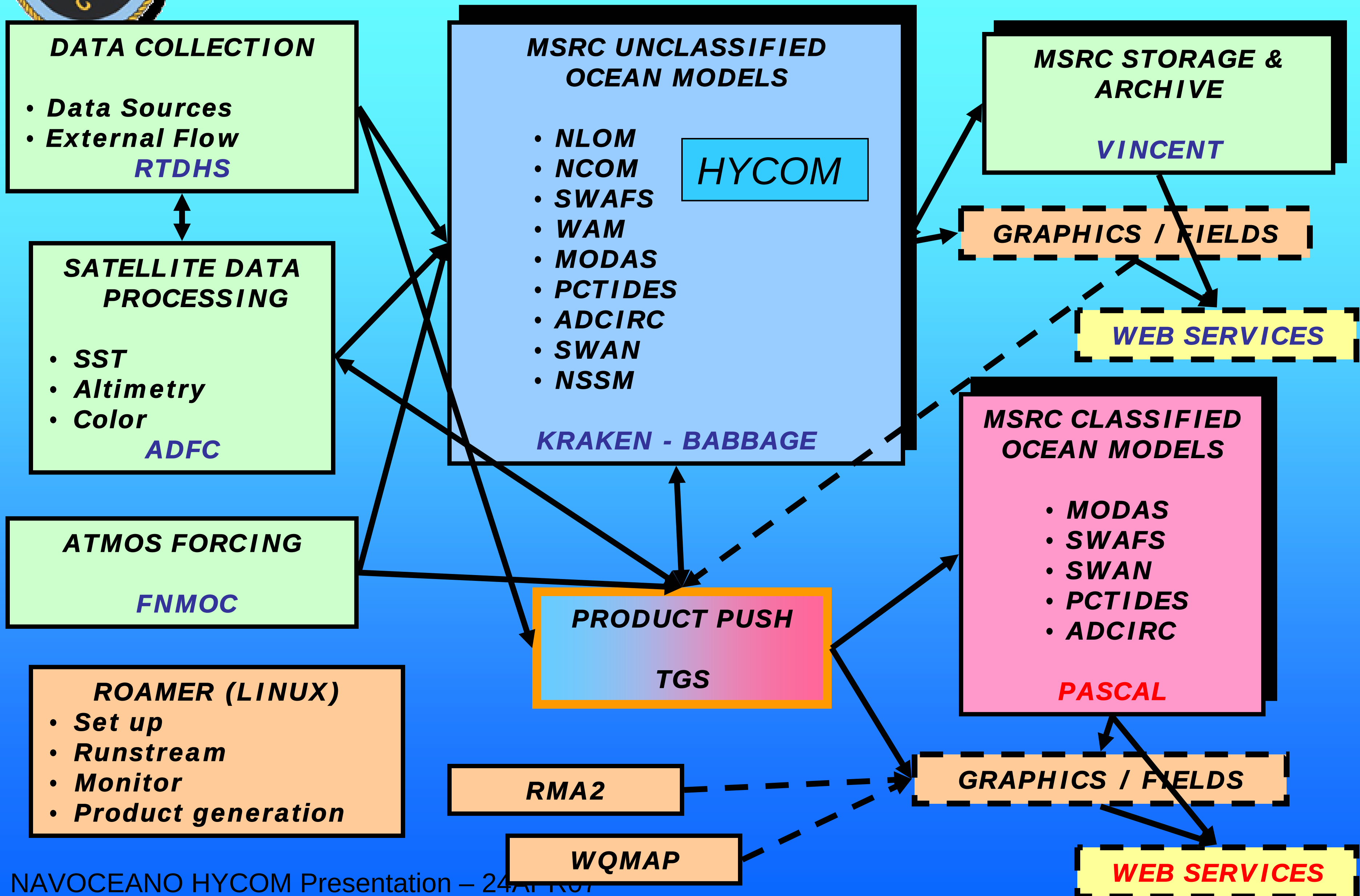
2. HYCOM INSTALLATION AT NAVOCEANO

- Fit into NAVO Infrastructure
- Use available data sources
- Constrained by MSRC computational power
- Comply with NAVO IT support
- Deal with NAVO/MSRC I/O constraints
- Web-based deliveries
- Fleet constraints and formats

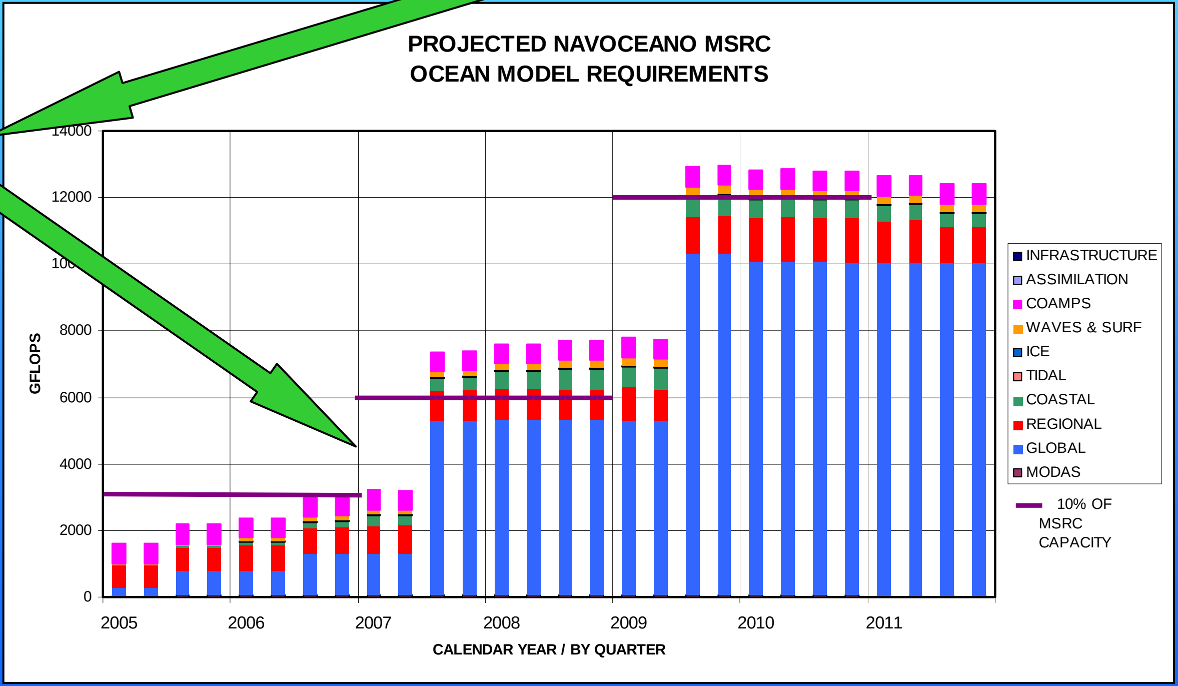
NAVOCEANO Models Data-Flow Wiring Diagram
(Simplified Version)



NAVOCEANO MSRC Assets - CY2007

SYSTEM		Speed	CPUS		15%	GFLOPS *			CPU-hours		
NAME	**MODEL**	**MHZ**	**TOTAL**	**AVBL**	**CNMOC**	**PER cpu**	**AVBL**	**CNMOC**	**AVBL**	**CNMOC**	**CLAS**
Babbage	Power-5+	**1,900**	3,072	2,912	437	7.6	22,131	3,320	69,888	10,483	**U**
Kraken	Power-4+	**1,700**	2,944	2,832	425	6.8	19,258	2,889	67,968	10,195	**U**
Pascal	Power-5+	**1,900**	1,920	1,792	269	7.6	13,619	2,043	43,008	6,451	**C**
			7,936	**7,536**	**1,130**		**55,008**	**8,251**	**180,864**	**27,130**	

Estimated FY07 requirements – 7,095 gigaflops or ~81% of projected capacity



* A **gigaflop** is defined as a billion (10^9) Floating Point Operations. This is calculated by multiplying the speed of a processor (CPU) times the number of CPUs used, times the wall clock time in seconds, to determine model "cycles" required. This is multiplied by 4 flops/cycle.

We Must be Mindful of Security Issues

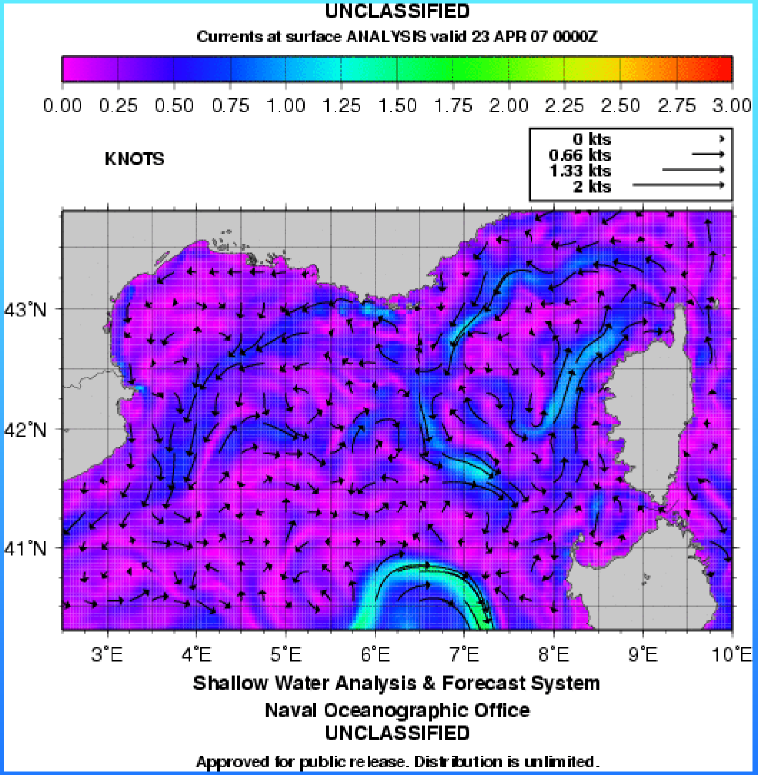
- Data flow constraints
- Navy access requirements
- Most fleet support is classified
- Totally open code

Strive for Standardized Input/Output

- MSRC upgrades every 2 years (IBM now, LINUX next?)
- Use ESMF
- Automatic jobstream runs
  - Ocean model operators not 24/7
  - Operator intervention by exception
- Log events to ROAMER
  - Inform operators / less experienced of progress /problems
- Maintain consistent look and feel
- Archive and deliver in a standardized format
  - NetCDF – 5D (properties, x-y-z, t)
  - Regular lat-lon grid
  - Properties T-S-U-V-E → sound speed, density, etc.
  - Save in tiles / blocks
- Conduct model assessments
  - Model to model comparisons
  - Consistent model-observation comparisons

We Need to Meet a Navy Schedule

- Navy cycle at sea
  - At 0800, the admiral's brief
  - At 2200, the plan for tomorrow goes out
- Daily hindcast – a reanalyses
  - Pick up SST/SSH analyses
  - Assimilate the latest observations
  - Revise start fields
- Forecast – has to be available to meet the morning schedule
  - Compress run times
  - May have to cut some cool stuff
  - 2-day, 3-day, 7-day products



SWAFS – Mediterranean Sea

Resources Are Always a Consideration

- Limited MSRC cycles
  - Competition from FNMOC, acoustics
- Delivery pipe – communications can be very restricted
  - Via WEB
  - Old days – JPEG graphics (150K/image)
  - Now – data for onboard computers
  - Looking for standardized compression
- Public delivery via NOAA Coastal Data Development Center (CDDC)

3. TRANSITION – SCIENCE TO OPERATIONS

- NRL Research does the science
  - Peer-reviewed papers
  - Validation test report (**VTR** - Navy / NOAA procedures)
  - **Milestone I**, move from basic research (6.1 / 6.2) to 6.4
- Install at NAVO with NRL running model
  - NAVO provides “operational cycles”
  - NAVO ocean model operators are trained
  - Fit into existing infrastructure
  - Establish feedbacks for improvements, corrections
  - Prepare users manuals, design documents
  - Move to meet schedule, output, skill requirements
  - **Milestone II** – demonstrate that model can run operationally

The Transition Process - 2

- NAVO “takes over”
  - Becomes part of the operations job stream and schedule
  - NAVO personnel troubleshoot, fix run problems
  - Conduct an **OPEVAL**
    - Demonstrate meets Navy requirements
    - Determine strengths and weaknesses
  - **Milestone III** – declare model operational
- Continuous feedback of issues to NRL
  - Example – MLD problems with NCOM
  - Warranty “tail”
- Use experience, emerging requirements for next cycle

In Summary

- NAVO models are developed to meet Navy requirements
  - ASW – sound speed forecasts
- The operating system is constrained
  - Available resources
  - Timetables
  - Security issues
  - Communications and delivery
- There is a transition process
  - Tested and declared operational for specific applications
  - A series of AMOP* milestones are to be met

* Administrative Modeling Oversight Panel